THE STRUCTURE AND CLASSIFICATION OF THE CONJUGATAE

WITH A REVISION OF THE FAMILIES AND A REARRANGEMENT OF THE NORTH AMERICAN GENERA

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The preceding papers on Diatoms[1] and Desmids[2] have prepared the way for a discussion of the structure and classification of the remaining family (Zygnemataceae) as well as of the whole order (Conjugatae). In the papers cited it has been assumed that the diatoms and desmids have descended from filamentous ancestors, and these plants are there regarded as still typically filamentous, the filaments in most cases undergoing early solution. This view does not regard the diatoms and desmids as properly unicellular plants, although the cells of these organisms are for the most part early isolated, and pass their lives in this condition.

The Pond Scums (Zygnemataceae) constitute a third family of the order Conjugatae, and here, while the filamentous structure is preserved, the adhesion of cell to cell is so feeble that fracture takes place very easily. Although the cells do not separate so as to exist singly, there is evidence that spontaneous fragmentation does occur, the result being the formation of short, few-celled filaments, comparable to the "hormogones" of the Cyanophyceae. This tendency to individuality in the cells is indicated by the fact that in adjacent cells one may be dead and the other in vigorous life, or one may have taken part in the formation of a zygote by a sexual act, while the other is still active vegetatively.

It may be assumed that these plants have been derived from other filamentous forms, and that the adhesion of cell to cell and the consequent formation of a multicellular plant body had become a well-

1 "The modern conception of the structure and classification of Diatoms," in *Transactions of the American Microscopical Society*, Vol. XXI, p. 61.

2 "The modern conception of the structure and classification of Desmids," in *Transactions of the American Microscopical Society*, Vol. XXII, p. 98.

established habit long before the peculiarities arose which set them off as Zygnemataceae. Now in any existing plants which may have given rise to the Zygnemataceae the individuality of the cells is distinctly subordinated to the individuality of the filament, and there is a much closer relation of cell to cell. Such groups as the Ulotrichaceae and Chaetophoraceae, with their highly individualized filaments, may have given rise to the Zygnemataceae, and in this paper I shall assume such relationship for purposes of comparison. In the families named the filaments are composed of proper cells (uninucleate), and the chromatophores, which are relatively large and few in number, vary from a single broad band which encircles the nucleus, to several narrow, longitudinal bands. The differences between these cells and those of the Zygnemataceae are little if any greater than those to be found within the limits of the families, and it is reasonable to suppose that the necessary structural changes may have occurred as here suggested.

In the Ulotrichaceae and Chaetophoraceae the plants are propagated mainly by zoospores, and also by the fragmentation of the filaments artificially, and possibly spontaneously. In the Zygnemataceae fragmentation has been much increased, and propagation by means of zoospores quite suppressed, possibly because of the fact that these plants float upon still waters where fragmentation alone provides amply for their propagation. Motile zoospores being thus quite needless have accordingly disappeared.

The quiet habitat of the Zygnemataceae doubtless had to do, also, with the change in the motility of the gametes. While in the other families mentioned the gametes are ciliated and actively motile, as indeed is quite necessary in the running waters which they inhabit, in Zygnemataceae no such activity is necessary; and here the sluggish gametes, no longer ciliated, are guided in their short journey by the device of tubular extensions of their cell walls. The whole process in these plants is a much more sluggish one than in the plants with which they are here compared.

There is thus a marked degeneration in the filament of the Zygnemataceae, which shows itself in its ready fragmentation, and in the greater sluggishness of the gametes in generation. Both of these tendencies receive greater emphasis in the Desmids and Diatoms where fragmentation is so marked that in most genera the cells are isolated for the greater part of their existence. It appears also

that the sluggishness in generation in the Zygnemataceae has been followed in some of the Desmids and Diatoms by a partial, if not complete, suppression of the sexual act. According to this view "conjugation," as the sexual act in the Conjugatae has been aptly called, is the result of degeneration. It is sexual reproduction on its way toward disappearance. Instead of affording an example of the *beginning* of sexuality, as has so often been suggested, these plants show sexuality on its way to *disappearance.*

These conceptions of the nature of these plants, and their relationship to other algae, require a considerable rearrangement in the sequence of the families and genera. In the papers cited above I have given expression to my ideas as to the proper sequence of the tribes and genera of the Desmids and Diatoms. The Zygnemataceae constitute so small a group that the task of arranging the genera in accordance with these ideas is not difficult. I have followed De Toni[3] in including the Mesocarpeae, which in my opinion do not differ sufficiently to be set off as a separate family. Wille,[4] on the contrary, regards the latter as entitled to family rank under the title Mesocarpaceae.

The order Conjugatae as here understood may be briefly characterized as follows:

Order CONJUGATAE

Plants microscopic, consisting typically of simple, unbranched rows of cells, often separating early into isolated cells; green, with lamelliform, taeniform (ribbon-like), or granular chromatophores, in one family yellowish by the addition of phycoxanthin; propagation by cell fission; generation by the union of the protoplasm of pairs of cells (conjugation, or aplanatic isogamy).

KEY TO THE FAMILIES.

A. Cells in cylindrical filaments	1. Zygnemataceae.
B. Cells mostly solitary, with cellulose walls	2. Desmidiaceae.
C. Cells mostly solitary, with siliceous walls	3. Bacillariaceae.

[3] Sylloge Algarum, by J. B. De Toni, p. 710. 1889.
[4] Die Natürlichen Pflanzenfamilien, by A. Engler and K. Prantl, Vol. I, Abt. 2. 1890.

Family 1. ZYGNEMATACEAE ("Pond Scums")

Cells with thin, smooth, cellulose walls, green, cylindrical, never constricted, always united into unbranched filaments; propagation by the accidental or spontaneous breaking of the filaments into short segments which grow directly into new plants; in some cases resting cells (aplanospores) are formed by a condensation of the cell contents and a thickening of the wall, these growing later into new plants; generation by the growth toward one another of tubular protrusions from adjacent or approximate cells and the formation of a continuous tube by the absorption of the contiguous end walls; through this tube the whole or part of the protoplasms of the two cells unite, either in one of the cell cavities or in the tube itself, forming a thick-walled resting-spore (zygote), which eventually grows directly into a new filament.—Minute fresh-water plants, floating on the surfaces of quiet pools and ponds.

KEY TO THE GENERA.

A. Whole contents of the conjugating cells entering the zygote.
  I. Conjugating tubes not septate.
    a. Chromatophores 1 or more, parietal, taeniform, spiral. 1. *Conjugata.*
    b. Chromatophores 2, stellate, axial, 2. *Lucernaria.*
    c. Chromatophore a single axial plate, 3. *Debarya.*
  II. Each conjugating tube with a septum at its base, chromatophores 2, stellate, 4. *Zygogonium.*
B. Part of the contents of the conjugating cells entering the zygote.
  I. Chromatophore a single axial plate, aplanospores none, 5. *Serpentinaria.*
  II. Chromatophore a single axial plate, aplanospores present, 6. *Gonatonema.*

1. *Conjugata* Vaucher (*Spirogyra* Link).[5]—Cells three to ten times longer than broad (rarely only as long as broad); transverse walls plane or with circular folds; chromatophores one or more, taeniform, parietal, spiral, each with several pyrenoids; nucleus centrally suspended; conjugation between two cells of different fila-

[5] Unfortunately the earlier name *Conjugata*, applied to these plants by Vaucher in 1803, must replace the well-known *Spirogyra* of Link, dating from 1820.

ments or of the same filament; zygote formed in one of the conjugating cells.—Species many, in fresh waters.

2. *Lucernaria* Roussel (*Zygnema* of authors).[6]—Cells as long as, or two to five times as long as broad; transverse walls plane; chromatophores two, axial, stellate, each with one pyrenoid; nucleus central, between the chromatophores; conjugation between two cells of different filaments or of the same filament; zygote formed in one of the conjugating cells, or in the conjugation tube.—Species many, in fresh waters.

3. *Dabarya* Wittrock.—Cells five to ten times as long as broad; transverse walls plane; chromatophore a single axial plate; conjugation between two cells of different filaments; zygote formed in the conjugation tube.—Species one, in fresh waters.

4. *Zygogonium* (Kützing) De Bary.—Cells from shorter than broad to twice as long; transverse walls plane; chromatophores two, axial, irregular (sometimes joined in an axial strand); conjugation between two cells of different filaments, the two protoplasms in the conjugation tube cut off from their cells by partitions before union; zygote formed in the conjugation tube.—Species two, in fresh water.

5. *Serpentinaria* S. F. Gray (*Mougeotia* Agardh).[7]—Cells many times as long as broad; transverse walls lenticular; chromatophore one, axial, lamelliform, with two or more pyrenoids; conjugation between two cells of different filaments, or of the same filament, only a part of the protoplasm of each cell uniting to form the zygote, which lies in the conjugation tube and is separated from the cells by partitions.—Species many, in fresh waters.

6. *Gonatonema* Wittrock.—Vegetative cells as in *Serpentinaria;* conjugation unknown; non-sexual spores (aplanospores) produced by the elongation of cells and the formation of a pair of partitions near the middle to separate the zygote-like cells.—Species two, in fresh waters.

[6] Here again it is unfortunate that we are obliged to displace the familiar name *Zygnema* of S. F. Gray and Agardh (1821 and 1824) for the earlier name *Lucernaria* proposed by Roussel in 1806.

[7] *Mougeotia* dates from 1824, when it was proposed by Agardh in his Systema Algarum, but this is antedated by *Serpentinaria* proposed by S. F. Gray in his Natural Arrangement of British Plants, published in 1821.

Family 2. DESMIDIACEAE ("Desmids")

See "The modern conception of the structure and classification of Desmids" in the *Transactions of the American Microscopical Society,* Vol. XXII, pp. 89 to 96, for a revision of the tribes and a rearrangement of the North American genera.

Family 3. BACILLARIACEAE ("Diatoms")

See "The modern conception of the structure and classification of Diatoms" in the *Transactions of the American Microscopical Society,* Vol. XXI, pp. 61 to 85, for a revision of the tribes and a rearrangement of the North American genera.